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# (54) Securing device

(57) A shape memory effect metal coil 1 which has unconnected free ends 2 and 3 is used to secure together two coaxial cylindrical objects by applying a radial force between them. The coil is expanded or contracted to exert the force by a change in temperature. To prevent subsequent temperature variations from reversing the securing action, the free ends can be fixed after the first expansion or contraction transition, e.g. by a block of solder 6 which melts and flows when the coil is heated to effect clamping. In another arrangement, a pawl and ratchet arrangement acting between the ends of the coil prevent reverse movement.

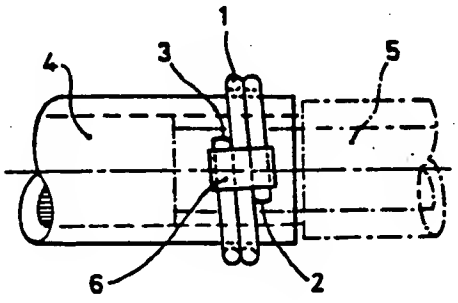


Figure 1a

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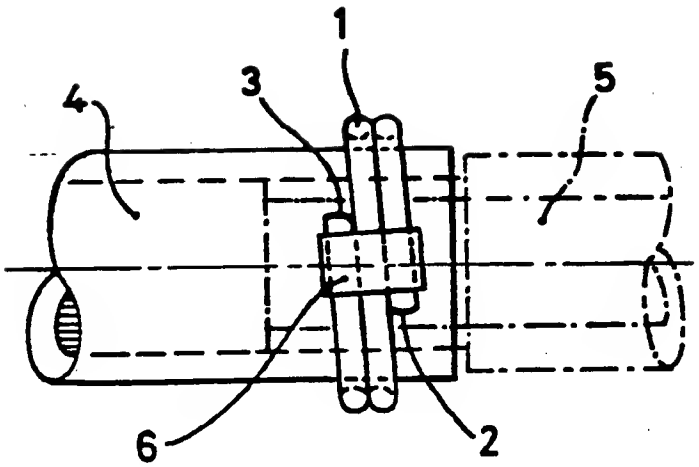


Figure 1a

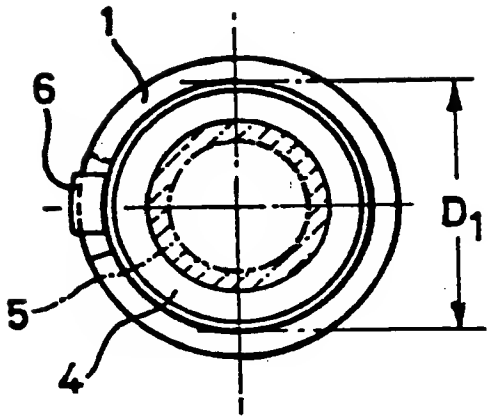


Figure 1b

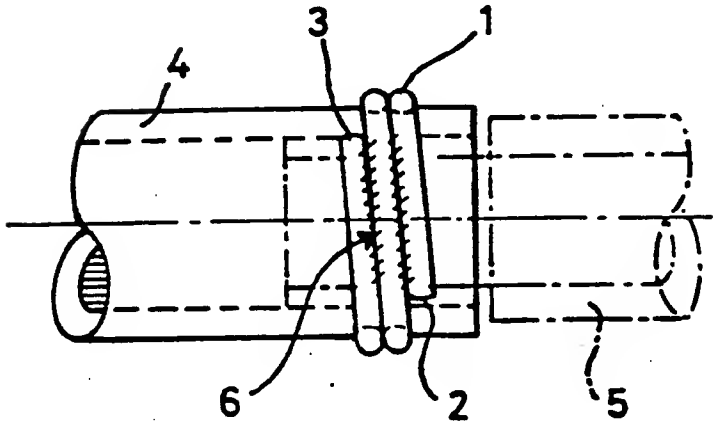


Figure 2a

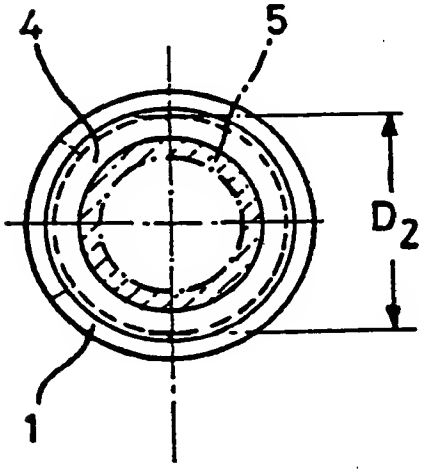


Figure 2b

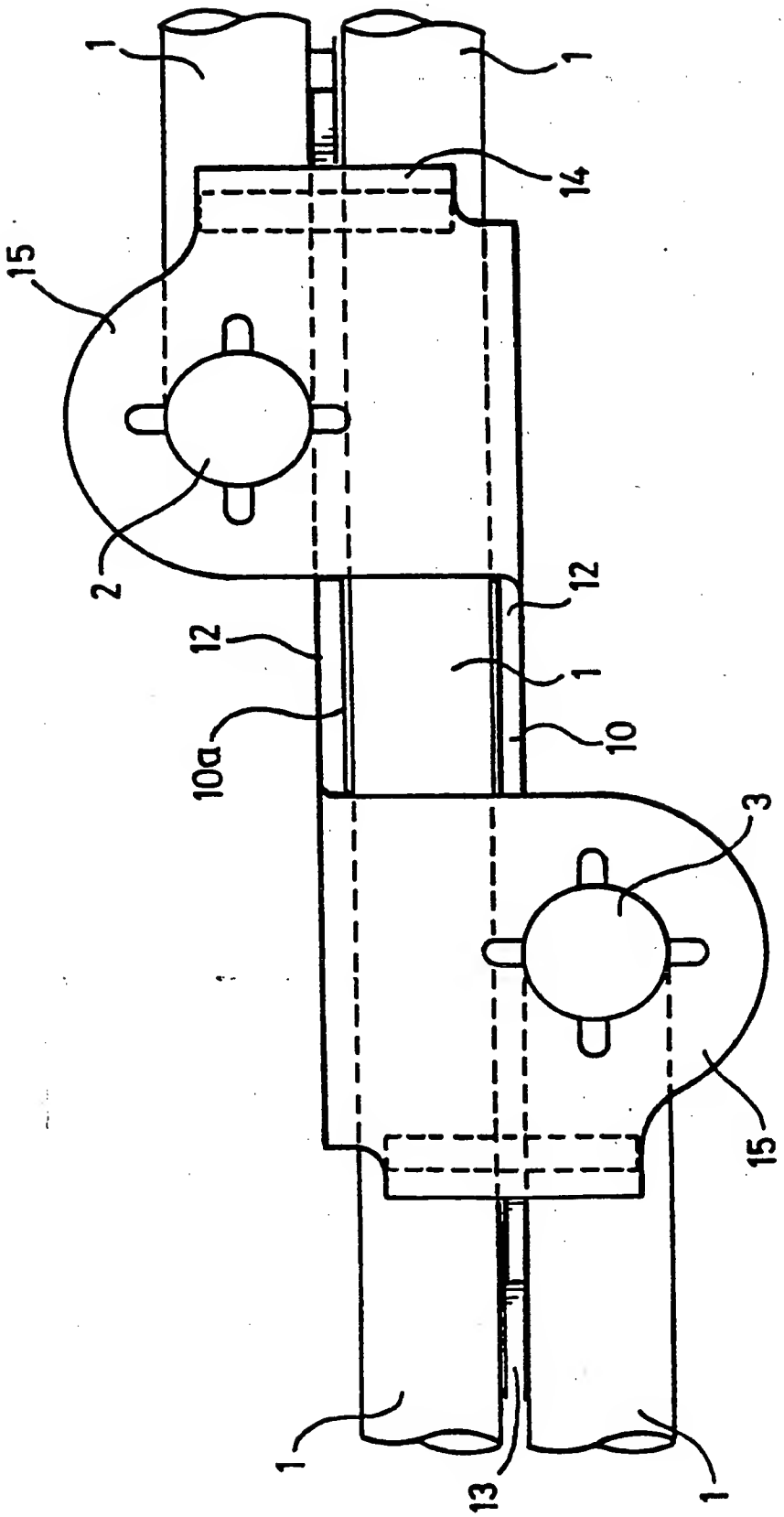


Figure 3

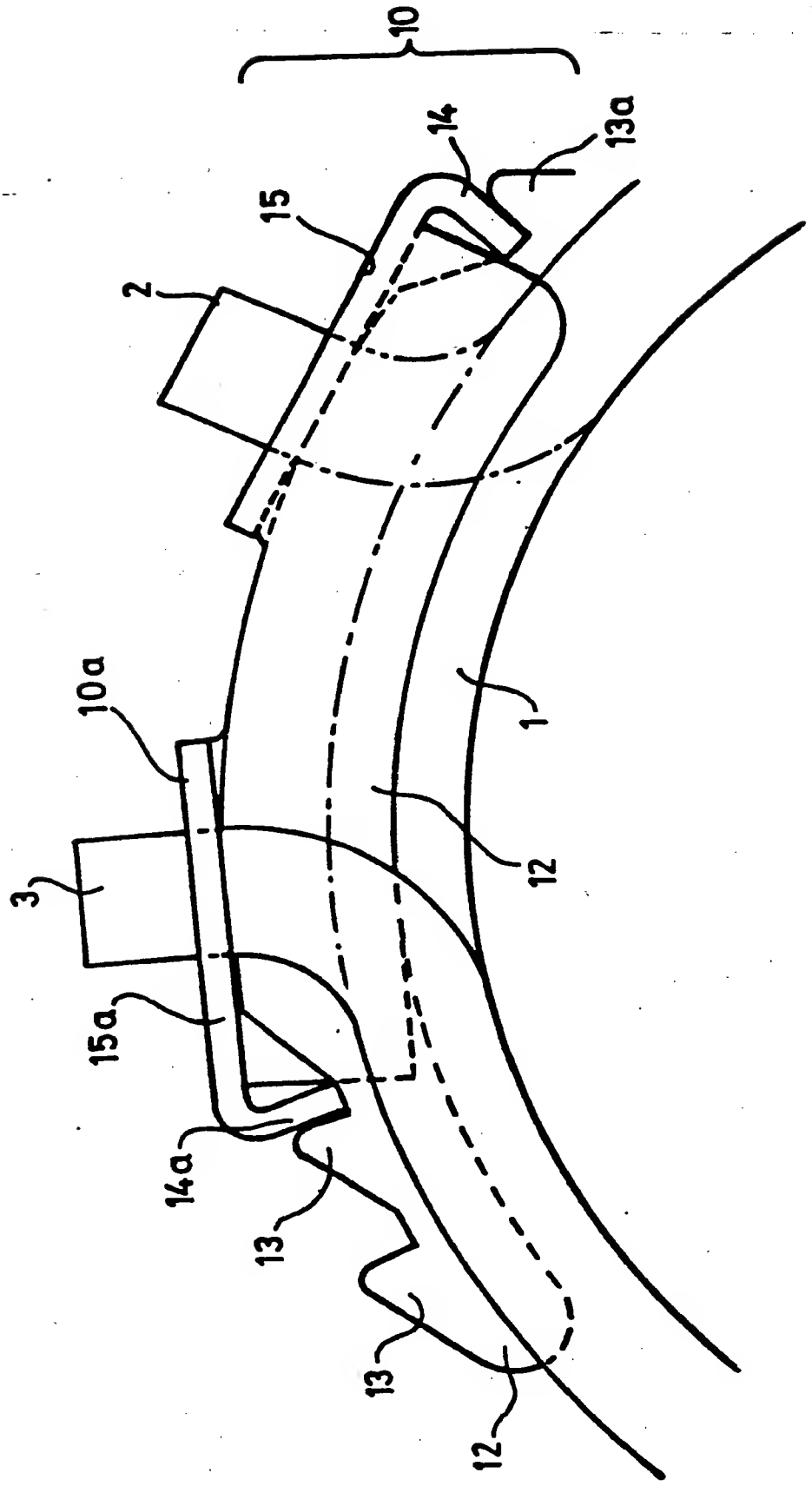


Figure 4

# SECURING DEVICE

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The present invention relates to a securing device, notably to a hose clip or the like made from a shaped memory effect metal.

## BACKGROUND TO THE INVENTION:

In high volume manufacturing processes, for example the manufacture of automobiles, many operations are now carried out by robots or computer controlled machines. However, there are some operations which are complex and require the use of more robots than seems economically justified. Thus, for example, the hoses used in an automobile engine to connect the engine and radiator require securing in place. This would conventionally be done using a jubilee clip. Such a clip requires the use of two robots, one to place the end of the hose over the spigot of the relevant part of the engine or radiator, and the other to tighten up the screw of the clip.

Surprisingly, we have found that an adequate clamping effect can be achieved by the use of a shape memory effect metal (hereinafter referred to as an SME metal) coil in which the free ends of the metal are not initially secured together, but are free to move relative to one another during part of the transition of the SME metal from one form to the other.

SUMMARY OF THE INVENTION:

Accordingly, the present invention provides a securing device adapted to engage with a substantially circular object, which device comprises a length of a shape memory effect metal formed into a coil having at least one turn and having the ends of the length free to move with respect to one another, the coil being adapted to contract or expand radially upon transition of the metal from the Austenitic to Martensitic form.

In a particularly preferred form, the device of the invention is made from an SME metal having a transition temperature within the operating temperature range of the object upon which it is to be mounted. The free ends of the length of metal from which the coil is made may be provided with fixing means for permitting relative movement of the ends to allow the coil to either expand or contract, but not both, as the SME metal cycles through its transition during operation of the object on which it is mounted. Effectively, such a means locks the coil in its desired configuration and does not allow the coil to change its dimensions as it cycles through its transition temperature.

The fixing means may comprise latching members carried at or adjacent each free end which co-operate to provide for the one way relative movement of the free ends, or may be provided by solder placed adjacent the free ends and which melts, flows and fuses to lock the coil.

The device of the invention finds widespread use wherever it is desired to expand or contract a coil radially onto a circular object and the coil can act radially inwardly, as

when it contracts, or outwardly as when it expands within a tube or the like. For convenience, the invention will be described hereinafter in terms of a coil which is to be contracted radially to grip a hose or the like onto a spigot.

The coil can be a simple single turn coil formed by winding a circular, square or other cross-section length of an SME metal upon a mandrel or the like. The free ends of the length of material overlap at one point on the coil. It is preferred that the coil have a number of turns, eg. 2 to 5 turns, and that the free ends of the length of metal are turned radially outwards to provided a pair of adjacent and upstanding prongs upon which the latching means can be mounted as described below and/or which provide means by which the coil can be handled and manoeuvred by a human or mechanical operator.

The coil can be made from an SME metal which has its transition temperature above, typically 50°C or more above, the maximum operating temperature to which it is expected that the coil will be subjected. In this case, the coil is made by winding the SME metal onto a mandrel or the like at ambient temperature. The coil is then mechanically expanded at ambient temperature to give a coil which is a push fit onto the hose on which it is to be used. When such a coil is heated to above its transition temperature to achieve the Austenitic form, it will contract to clamp the hose onto the spigot.

However, the use of an SME metal having a transition temperature which is sufficiently high to lie at all times above the expected maximum operating temperature to be encountered may lead to problems during the assembly of the coil on the hose and spigot. Thus, the degree of heating required is costly and carries fire and injury risks.

Furthermore, it may be necessary to heat the coil to about 200°C in order for the SME metal from which it is made to transform into its Austenitic form and thus contract. The materials from which the hose is made may be damaged by such a high temperature.

Surprisingly, we have found that advantages can be achieved if the coil is made from an SME metal having a comparatively low transition temperature, so that it can be manufactured and installed at temperatures which will usually be well below that at which the above problems arise.

At first sight, it would seem illogical to use a material whose transition temperature was within the operating temperature range expected for the object on which it is to be mounted. This would have been expected to result in repeated cycling of the coil through its transition temperature and to relaxing of the coil so that it would cease to grip the object. However, according to the preferred embodiment of the invention, the free ends of the coil are prevented from relative movement during the expansion transition of the coil so that the coil is mechanically retained in the contracted configuration at all times and will not release the hose.

In this version of the device of the invention, the coil is

formed and expanded at room temperature as described above. However, the means for fixing the free ends of the coil are then mounted on the expanded coil and the assembled coil mounted on the hose. When the hose is secured in place, the coil is heated to above the transition temperature of its SME metal to cause it to contract. The fixing means then operates to secure the coil against re-expansion as the coil cools. Effectively, the coil no longer acts as if it were made from an SME metal, but has a fixed configuration throughout any subsequent cycling through the transition temperature.

The prevention of the relative movement of the free ends of the coil during the expansion transition of the SME metal can be achieved in a number of ways. Thus, the free ends can be permanently secured together after the coil has been contracted in place, for example by soldering or glueing the ends of the coil in place so that the coil permanently adopts the contracted configuration. However, it may be advantageous to allow the coil to contract further if required by the use of a unidirectional fixing together of the free ends of the coil. Thus, the free ends of the coil can be formed as retro-angled hooks which travel over one another during contraction of the coil, but which interlock with one another as the coil tries to expand. Alternatively, the ends can be journalled in a sprung sleeve and carry co-operating ratchet teeth which allow the ends to move past each other in one direction, but which lock together if movement in the opposite sense occurs.

The invention also provides a method of securing a hose on a spigot, the method comprising the steps of placing a securing device around the hose, the device comprising a length of a shape memory effect metal formed into a coil

having at least one turn and having the ends of the length free to move with respect to one another and the initial diameter of the coil being greater than the external diameter of the hose, placing the hose on the spigot, subjecting the coil to heat whereby the coil contracts to secure the hose to the coil, and fixing the ends of the coil to retain the coil in its contracted state.

It will be appreciated that the invention has been described above in terms of a coil which is to be expanded when cold to give a Martensitic form of the coil with a large diameter which is then shrunk onto the hose and spigot with the securing means preventing re-expansion of the coil. Where the coil is to be used to act radially outwardly in a tube, the coil will be mechanically contracted radially when cold, expanded by heating and the fixing means then acts to prevent contraction of the coil.

The coil can be made from a wide range of SME metals, for example alloys of titanium and nickel, copper and zinc and such alloys modified by the incorporation of other metals such as aluminium or other additives to adjust the transition temperature to within the desired range. Preferably, the SME metal will have a transition temperature in the range -10 to + 100°C, notably 20 to 80°C, where it is used in the preferred form of the device of the invention.

The size of the coil, the number of turns therein and the thickness of the SME metal used to construct the coil can be selected in known manner having regard to the operating conditions to be encountered and the tension which the coil is to apply. Typically, for use in securing a hose on a spigot, it will be required that the coil show a change of diameter of at least 5% in its unloaded state as it passes through the transition point of the SME metal.

PREFERRED EMBODIMENT OF THE INVENTION:

The invention will now be described, by way of example, with reference to the accompanying drawings, in which

Figure 1a is a side view of a first embodiment of securing device in accordance with the invention; in position on a pipe/hose joint;

Figure 1b is a section through the joint of Figure 1a;

Figure 2a shows the device of Figure 1a in its secured position;

Figure 2b is a section through the joint of Figure 2a;

Figure 3 is a plan view of a latch mechanism for fixing the free ends of an SME metal coil; and

Figure 4 is a side elevation of the mechanism of Figure 3.

An SME coil 1 is made by close winding two turns of a copper/zinc/aluminium alloy square or round section wire upon a suitable mandrel. The coil is then twisted about its longitudinal axis or otherwise mechanically expanded radially so that it is a push fit onto a hose 4, and the hose is a push fit onto a spigot 5.

At this point, the internal diameter $D_1$ of the coil 1 is slightly greater than the external diameter of the hose 4. When the coil 1 is heated to its transition temperature, it

contracts to an internal diameter $D_2$ which is less than the external diameter of the hose, and as a result the hose is clamped to the spigot.

In order to prevent this clamping process operating in reverse when the coil cools, the free ends 2 and 3 of the coil can be locked. In Figures 1 and 2, a block of solder material 6 is placed on the coil adjacent the ends 2 and 3. When the coil is heated, the solder melts, flows between the turns of the coil and then solidifies to fix the coil ends and to prevent the coil from expanding again.

Figures 3 and 4 show an alternative mechanical latch for fixing the free ends 2, 3. The free ends 2 and 3 of the wire are bent into radially outward projections.

Upon each free end of the expanded coil is mounted a latch member 10, which comprises an arcuate web 12, which is located between the turns of the coil adjacent the free end. The web 12 has at one end thereof a series of detent teeth or notches 13 and at the other end a catch 14 which is offset to one side of the plane of the web 12 so that it will overlie and engage with the detents 13a carried by the other latch member 10a mounted on the other free end. The detents 13 and the catch 14 are configured so that they will allow the free ends of the coil to move relative to each other when the coil contracts (anti-clockwise for 10 relative to 10a in the mechanism shown in Figure 4) but not when the coil attempts to expand again as it cools or during cycling through the transition temperature of the metal.

The latch members 10 and 10a can be made from steel or other suitable metals by drop forging, stamping or any other technique.

The members 10 and 10a are mounted upon the free ends of the expanded coil by inserting the webs 12 and 12a between turns of the coil and locating the free ends 2 and 3 through apertures in the transverse plates 15 and 15a carried by the webs and from which the catches 14 and 14a are dependant.

The coil carrying the latch members is fitted, eg. as a tight push fit, onto the end of a hose in the same manner as a conventional jubilee clip and the hose is assembled onto the spigot. The hose end is then heated to cause the coil to contract and clamp the hose firmly onto the spigot. The latches 10 and 10a ride over one another during the contraction of the coil to allow the free ends of the coil relative movement. The coil is then allowed to cool, so that it would want to re-expand to adopt the expanded configuration of its Martensitic form. However, the relative movement of the free ends is prevented by the engagement of the detents 13 and catches 14 on the opposed latch members 10 and 10a. As a result, when the coil cools through the transition temperature of the SME metal, the coil will be held in the contracted configuration applying radial pressure to clamp the hose in position and the coil is not allowed to relax as would occur if the ends were left free to move.

As indicated above, the device of the invention finds widespread use where ever it is desired to clamp radially onto an object. The clamping can be directed radially inwardly as described above. However, it will be appreciated that the high temperature form may be the larger diameter form so that the coil expands radially outwardly to push against the inner wall of a cylinder or the like. Thus, the device of the invention can be used to clamp a sleeve within a cylinder or to act as a circlip within a circumferential groove. Where the coil is to be used within

a cylinder or the like, it will usually be desirable that the free ends of the coil be directed inwardly rather than outwardly as shown in Figure 2.

It will also be appreciated that although the invention has been described above in terms of the use of heat the change of the coil from its quiescent form to its active form, ie the contraction or expansion, can be caused by a reduction rather than an increase in temperature.

CLAIMS:

1. A securing device adapted to engage with a substantially circular object, which device comprises a length of a shape memory effect metal formed into a coil having at least one turn and having the ends of the length free to move with respect to one another, the coil being adapted to contract or expand radially upon transition of the metal from the Austenitic to Martensitic form.

2. A device as claimed in Claim 1 wherein the free ends of the length of metal are provided with fixing means for permitting initial relative movement through one expansion or contraction transition whilst preventing subequent movements.

3. A device as claimed in Claim 2 wherein the first expansion or contraction transition occurs when the metal is subjected to an elevated temperature, and the fixing means comprises solder which flows around and then solidifies to secure the free ends.

4. A device as claimed in Claim 3, wherein a block of solder is attached to the coil adjacent the free ends.

5. A device as claimed in Claim 2, wherein the fixing means comprises a pair of latching members, one attached to each free end, which cooperate to allow relative movement between the free ends in one direction but not in the opposite direction.

6. A device as claimed in Claim 5, wherein each latching member has a set of ratchet teeth at one end and a ratchet pawl at the other end, the pawl on one member engaging with the teeth of the other member.

7. A device as claimed in Claim 5 or Claim 6, wherein the free ends extend radially outwards from the coil to receive the latching members.

8. A device as claimed in any preceding claim, wherein the coil has between 2 and 5 turns.

9. A device as claimed in Claim 2, wherein the free ends of the coil are formed as retro-angled hooks which travel over one another during contraction of the coil but which interlock with one another as the coil tries to expand.

10. A device as claimed in Claim 2, wherein the free ends are journalled in a sprung sleeve and carry co-operating ratchet teeth which allow the ends to move past each other in one direction, but which lock together if movement in the opposite sense occurs.

11. A method of securing a hose on a spigot, the method comprising the steps of placing a securing device around the hose, the device comprising a length of a shape memory effect metal formed into a coil having at least one turn and having the ends of the length free to move with respect to one another and the initial diameter of the coil being greater than the external diameter of the hose, placing the hose on the spigot, subjecting the coil to heat whereby the coil contracts to secure the hose to the coil, and fixing the ends of the coil to retain the coil in its contracted state.

12. A method as claimed in Claim 11, wherein the SME metal has a transition temperature within the operating temperature range of the hose on the spigot.

13. A method as claimed in Claim 11, wherein the SME metal has a transition temperature above the maximum operating temperature of the hose on the spigot.

14. A securing device substantially as herein described with reference to any one embodiment shown in the accompanying drawings.

15. A method of securing a hose on a spigot substantially as herein described with reference to the accompanying drawings.

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